Ackerman, Joyce

From:	Thomas J. Krasovec <TJKrasovec@Geosyntec.com>
Sent:	Thursday, February 8, 2018 6:34 PM
To:	Ackerman, Joyce
Subject:	Alternatives Evaluation
Attachments:	Alternatives Evaluation.xlsx

Joyce,

As requested, we have been evaluating the options for addressing the impacted soils at the Neuhauser site to develop the best alternatives for the short-term removal and long term remedial actions. These assessments have included the technologies shown on the attached list, as well as obtaining costs from several contractors to complete the work. The general work in progress on remedial assessments includes the following:

- Pursuing capabilities and quotes from onsite thermal and chemical oxidation contractors. We are also evaluating the time frames that the various contractors can meet.
- Evaluating the potential for in-situ oxidation to treat materials at the bottom of the excavation (e.g., bedrock), and to create a longer-term treatment zone for groundwater.
- Developing potential site-specific soil removal criteria, which we will provide very soon.
- Our intentions are to continue the drum removal and sludge removal and clean up, and to provide more details on the selected options for dealing with the large amount of soils as soon as possible, pending ongoing investigations. We will also continue test pitting on the property in coordination with the CDPHE to identify additional drums located on the property.
- We will likely propose that the worst soils be treated above grade with some residual soils treated in situ. It is likely we will present our thoughts on the proposed criteria for making the foregoing determination. We understand that the insitu work will require additional assessment in the field to verify the remaining depths of the impacted soils. We will coordinate with EPA on the extent of the needed exploration and with ACT on timing of the work based on equipment and personnel availability.

Please let us know if you have any questions. To the extent we obtain significant additional information on the forgoing we will provide an update prior to our meeting scheduled for Tuesday Afternoon.

Thanks TJK

Thomas J Krasovec
Senior Professional
Geosyntec Consultants
Ph: 720-509-8911
Cell: 517-719-4984
Geosyntec Consultants, Inc.
5670 Greenwood Plaza Blvd, Suite 540
Greenwood Village, CO 80111

Table 1
Identification and Initial Screening of Remedial Technologies and Process Options

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Retained for Alternative Development?
No Action	No Action	No Action	Take no remedial action.	Not effective in reducing contaminant concentrations, mobility, or potential threat to human health and the environment. Also not effective at identifying when a potential threat to human health and the environment may exist or develop.	Readily implementable.	No Capital, No O&M.	No
Institutional Actions	Monitoring	Groundwater Monitoring (Wells)	Periodically sample and analyze groundwater to monitor and document changes in VOC concentrations over time.	Effective for providing data with which to assess risk, but not effective in reducing contaminant concentrations, mobility, or potential threat to human health and the environment.	Already implemented. A monitoring well network is present and a monitoring program is in place for the Site.	Low Capital, Low O&M.	**Yes**
		Surface Water Monitoring	Periodically sample and analyze surface water to monitor and document changes in VOC concentrations over time.	No surface within the plume footprint at the Site; therefore not applicable.	Not applicable.	NA	No
		Vapor Intrusion (VI) Evaluation/Monitoring	Conduct a VI risk evaluation in current and/or future inhabitable structures located above the areal extent of the groundwater VOC plume.	Effective for providing data with which to assess risk, but not effective in reducing contaminant concentrations, mobility, or potential threat to human health and the environment.	No inhabitable structures are currently located within the plume footprint at the Site; expect to remediate soil and groundwater prior to construction of inhabitable structures at the Site.	Low Capital, Low O&M.	No
	Use Restrictions	Institutional Restrictions	Restrict groundwater use to limit potential exposures to contaminated groundwater.	Effective for providing long term risk reduction by restricting the use of Site groundwater.	Readily implementable.	Low Capital, Low O&M.	**Yes**
		Alternate Water Supply	Provide an alternate water supply to all users of potentially affected groundwater.	No users of groundwater as water supply impacted; therefore not applicable.	Not applicable.	NA	No
		Point of Use Controls	Provide well head treatment (e.g., carbon canisters) to wells screened in affected groundwater.	No users of groundwater as water supply impacted; therefore not applicable.	Not applicable.	NA	No
Collection/ Containment	Extraction	Excavation and Off-Site Disposal	Excavate and dispose of impacted soils at an off-site landfill or hazardous waste disposal facility.	Effective and reliable as long as impacted soils are fully delineated and excavated. Transports contaminants to another location rather than treating, reusing, or recycling on Site.	Readily implementable.	High Capital, Low O&M.	**Yes**
		Extraction Wells	Extract contaminated groundwater and control groundwater migration using extraction wells. Extracted groundwater is treated ex-situ and discharged to surface or injected back into aquifer.	Extraction would require operation for a long time as dissolved groundwater concentrations would likely persist due to slow desorption of VOCs from organic and geologic materials.	Readily implementable, but requires construction of extraction and treatment system. O&M demands would be frequent and likely necessary for an extended time.	Moderate Capital, High O&M.	No
		Extraction Trench	Install trenches backfilled with porous media to collect contaminated water. Groundwater is pumped out to remove VOC mass and control groundwater migration. Extracted groundwater is treated ex-situ and discharged to the surface or injected back into the aquifer.	Extraction would require operation for a long time as dissolved groundwater concentrations would likely persist due to slow desorption of VOCs from organic and geologic materials.	Readily implementable, but requires construction of extraction and treatment system. O&M demands would be frequent and likely necessary for an extended time.	Moderate Capital, High O&M.	No
		Phytoremediation (for groundwater flow control)	Plant selected species of trees to affect groundwater flow direction and reduce the risk of migration of groundwater off-site.	Potentially effective. At other sites, groves of trees have been demonstrated to create potentiometric depressions that influence groundwater flow direction; however, high VOC concentrations may be toxic to trees, and it may take several years for roots to reach groundwater at the site.	Readily implementable. Requires several years for plant species to become established.	Moderate Capital, Low O&M.	No
	Containment	Landfill Cap/Water Balance Cap	Place soil and/or geosynthetics above wastes to minimize exposure on the surface, and to prevent vertical infiltration of water that could leach out contaminants.	Effective in reducing exposure to contaminants via surface soil and reducing contaminant leaching in the vadose zone, but not effective in reducing contaminant concentrations or contaminant mobility below the water table.	Readily implementable. CDPHE has indicated that a water balance cap will be required as part of closure of the landfill in general.	Moderate Capital, Low O&M.	**Yes**
		Vertical Barrier Walls	Create a physical barrier to control horizontal migration of contaminated groundwater. The barrier may be constructed using native soils enriched with bentonite (or other clay) or cement, or using geomembranes, grout curtains and steel sheet piling, either separately or in combination.	Potentially effective in controlling migration of contaminated groundwater if entire source area is encompassed; however, not effective in reducing contaminant concentrations, mobility, or potential threat to human health and the environment.	Readily implementable. Requires construciton of vertical barrier walls.	High Capital, Low O&M.	No

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General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Retained for Alternative Development?
	Monitored Natural Attenuation (MNA)	Naturally occurring biological and chemical degradation processes, as well as physical attenuation processes (sorption, dispersion, dilution, dissolution, etc.)	Conduct long-term monitoring of the natural attenuation and biotic and abiotic degradation/transformation of contaminants. Implementation would include monitoring of secondary parameters (e.g., breakdown products, nutrient levels, geochemical parameters) in addition to contaminant concentrations.	This alternative will not actively reduce COC concentrations or mass flux. Some natural attenuation of COCs will likely occur through physical, biological, and chemical processes. These would be documented through the MNA monitoring program.	Readily implementable.	Low Capital, Low O&M.	**Yes**
	Biological Treatment	Bioventing/Biosparging	Inject air (or oxygen) and/or nutrients into the saturated zone to increase the biological activity of the indigenous microorganisms.	Treatment is on the order of years. Effective in aerobic groundwater environment if properly distributed and necessary bacteria present.	Readily implementable, but requires construction of bioventing/biosparging system. O&M demands would be frequent and likely necessary for an extended time.	Moderate Capital, High O&M.	No
		Enhanced Bioremediation (Reductive Dechlorination)	Inject or emplace microbes, nutrients and/or other amendments into groundwater through injection wells or as a permeable reactive barrier installed via injection/jetting techniques to enhance biological degradation in-situ.	Treatment is on the order of years. Effective and reliable in anaerobic groundwater environment if properly distributed and necessary bacteria present or added. Effective for chlorinated solvents, but not 1,4-dioxane.	Readily implementable, but requires construction of injection wells. Multiple injections will likely be necessary, and will likely take several years for COC concentrations to reach objectives.	Low Capital, Low O&M.	**Yes**
		Phytoremediation (for contaminant degradation)	Plant selected species of trees to remove, transfer, stabilize and destroy organic contamination in groundwater.	Treatment is on the order of several years. Effective for low to moderate level VOC concentrations, but the high VOC concentrations found at the site may be toxic to trees, and it may take several years for roots to reach groundwater at the site.	Readily implementable. Requires several years for plant species to become established.	Moderate Capital, Low O&M.	No
	Chemical Treatment	Chemical Oxidation (ISCO)	Insert oxidants such as permanganate, hydrogen peroxide, or persulfate into groundwater via injection wells or in-situ soil blending. Oxidation reactions chemically convert VOCs to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert.	Treatment is on the order of years. Effective and reliable if properly distributed. Effective for VOCs and 1,4-dioxane.	Readily implementable. Oxidants could be added via in-situ soil blending or injection via injection wells. Multiple injections likely necessary. Oxidants are hazardous materials requiring special safety precautions.	Moderate Capital, Low O&M.	**Yes**
In-Situ Treatment		Chemical Reduction (ISCR)	Insert reductants such as nanoscale or microscale zero valent iron into groundwater via injection wells or in-situ soil blending. Reduction reactions chemically convert contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert.	Treatment is on the order of years. Effective and reliable if properly distributed. Effective for chlorinated solvents, but not 1,4-dioxane.	Readily implementable, but requires construction of injection wells. Multiple injections will likely be necessary. Reductants may be hazardous materials requiring special safety precautions.	High Capital, Low O&M.	No

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	Biological/Chemical Treatment	Combined Chemical/Biological Reduction	Inject sulfate and/or iron in conjunction with an electron donor substrate to enhance reducing conditions in an aquifer and promote chemical and biological reductive dechlorination.	Treatment is on the order of years. Effective and reliable in sulfate/iron deficient anaerobic groundwater environment if properly distributed and necessary bacteria present or added. Effective for chlorinated solvents, but not 1,4-dioxane.	Readily implementable, but requires construction of injection wells. Multiple injections will likely be necessary.	Moderate Capital, Low O&M.	No
	Physical Treatment	Air Sparging/Soil Vapor Extraction (SVE)	Inject air into the saturated zone to volatilize VOCs, which are collected in the unsaturated zone by a soil vapor extraction (SVE) system for ex-situ treatment.	Treatment is on the order of years. Effective and reliable within radius of influence. Effective for VOCs, but not 1,4-dioxane.	Readily implementable, but requires construction of air sparging/SVE wells and treatment system.	Moderate Capital, High O&M.	**Yes**
		In-Well Air Stripping	Inject air into the water column to volatilize VOCs. Groundwater is circulated in-situ, with groundwater entering the well at one screen and discharging through a second screen. Air is collected in the unsaturated zone by a SVE system for ex-situ treatment.	Treatment is on the order of years. Effective and reliable within radius of influence. Effective for VOCs, but not 1,4-dioxane.	Readily implementable, but requires construction of in-well air stripping wells and treatment system.	Moderate Capital, High O&M.	No
		Solidification/Stabilization	Add material to encapsulate the waste and form a solid, coat the waste with low permeability materials, and/or react chemically to reduce leaching. Can be accomplished by mechanical processes or chemical reactions (e.g., cement).	Treatment is on the order of weeks to months. Effective and reliable as long as impacted soils are fully delineated and solidified/stabilized. Reduces contaminant mobility, but not effective in reducing contaminant concentrations. Limited effectiveness for organics.	Readily implementable. Requires specialized tooling for in-situ soil mixing.	High Capital, Low O&M.	**Yes**
	Electrokinetics (EK)	Electrokinetic Enhanced Reagent Transport	Apply low direct current voltage gradients to the subsurface through simple electrodes, resulting in the migration of ions towards their oppositely charged electrode. EK-enhanced migration can be used to improve delivery of ionic reagents for various treatment technologies (e.g., EISB or ISCO) in low permeability environments.	Treatment is on the order of months to years. Effective in low permeability environments where hydraulic delivery approaches are difficult or impractical.	Potentially implementable. Requires construction of in-situ EK system, which is potentially difficult to construct on short notice.	Moderate Capital, High O&M.	No
	Thermal Treatment	Electrical Resistance Heating, Hot water/steam injection, Thermal Conduction	Heat the subsurface to volatilize contaminants and recover using SVE for ex-situ treatment. Heating methods may include: electrical current applied through a series of electrodes, injection of hot water and/or steam, and thermal conduction via steel wells.	Treatment is on the order of months. Effective and reliable for VOCs, potentially effective for 1,4-dioxane.	Potentially implementable. Requires construction of in-situ thermal treatment system, which is potentially difficult to construct on short notice.	High Capital, High O&M.	No
	Biological Treatment	Biopiles, Composting, Landfarming	Mix excavated soil with organic amendments to enhance biodegradation of contaminants. Moisture, heat, aeration, and/or pH usually need to be adjusted to sustain biodegradation.	Treatment is on the order of several months. Effective and reliable if proper amendments added and properly mixed. Effective for chlorinated solvents, but not 1,4-dioxane, which is not readily biodegraded. Contaminants are degraded to non-toxic end products.	Readily implementable. Relatively easy to acquire amendments. Leachate collection system necessary, as well as aeration system (blowers, vacuum pumps, or mechanical turning). Moisture, heat, nutrients, oxygen, and pH may need to be controlled to enhance biodegradation. Off-gas treatment may be necessary to control odors.	Moderate Capital, Low O&M.	No
	Chemical Treatment	Chemical Extraction	Mix excavated soil with an extracting chemical (e.g. acid or solvent) to dissolve the contaminants. The solution is then separated into extractant and contaminants for further use and treatment.	Treatment is on the order of weeks to months. Extraction may be less effective for the higher clay content observed in Site soils. Effective for Site contaminants. Residual acid or solvent may be left on soils. Contaminant mass is permanantly removed from the subsurface.	Potentially implementable. Potentially difficult to acquire extracting acid or solvent and mixing vessel on short notice. Off-gas treatment may be necessary to control odors. Extracting acid or solvent may be hazardous materials requiring special safety precautions.	High Capital, Low O&M.	No
		Chemical Reduction/Oxidation	Mix excavated soil with oxidants or reductants such as ozone, hydrogen peroxide, hypochlorites, chlorine, or chlorine dioxide. Redox reactions chemically convert VOCs to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert.	Treatment is on the order of weeks to months. Effective and reliable as long as impacted soils are fully delineated. Chemical reduction is no effective for toluene or 1,4-dioxane; chemical oxidation is effective for VOCs and 1,4-dioxane.	Readily implementable. Relatively easy to acquire amendments. Off-gas treatment may be necessary to control odors.	Moderate Capital, Low O&M.	**Yes**

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General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Retained for Alternative Development?
Ex-Situ Treatment		Dehalogenation	Mix excavated soil with reagents (e.g. sodium bicarbonate or an alkaline polyethylene glycol) and heat. Dehalogenation of contaminants occurs by replacement of halogen molecules or decomposition and partial volatilization of contaminants.	Treatment is on the order of weeks to months. Only provides partial decomposition of halogenated contaminants.	Potentially implementable. Potentially difficult to heat soil due to lack of power at the Site.	High Capital, Low O&M.	No
	Physical Treatment	Separation	Gravity or magnetic separation can be used to detach contaminants from soil by physical means. Sieving can be used to separate fine soil with sorbed contaminants, which concentrates contaminants into a smaller soil volume.	Treatment is on the order of months. Gravity separation is effective if contaminant is in a different phase (e.g. liquid NAPL). Magnetic separation can be effective for metals. Sieving can be effective if contaminants are sorbed onto fine soil particles, but impacted soil must then be treated or disposed of.	Readily implementable. Treatment or disposal of impacted soil necessary.	Moderate Capital, Low O&M.	No
		Soil Washing	Mix excavated soil with water to dissolve and suspend contaminants in the wash solution, and separate fine soil with sorbed contaminants, which concentrates contaminants into a smaller soil volume. The wash water may be augmented (e.g. leaching agent, surfactant, chelating agent, or pH adjustment) to help remove contaminants.	Treatment is on the order of months. Effective for SVOCs, fuels, heavy metals, and some VOCs and pesticides, but mixtures of these compounds make it difficult to formulate effective wash fluids. Can be effective if contaminants are sorbed onto fine soil particles, but impacted soil must then be treated or disposed of.	Readily implementable. Treatment or disposal of impacted soil necessary.	Moderate Capital, Low O&M.	No
		Solidification/Stabilization	Mix excavated soil with material to encapsulate the waste and form a solid, coat the waste with low permeability materials, and/or react chemically to reduce leaching. Can be accomplished by mechanical processes or chemical reactions (e.g., cement).	Treatment is on the order of weeks to months. Effective and reliable as long as impacted soils are fully delineated and solidified/stabilized. Reduces contaminant mobility, but impacted soil must then be disposed of. Limited effectiveness for organics.	Readily implementable. Disposal of solidified/stabilized soil necessary.	High Capital, Low O&M.	No
	Thermal Treatment	Incineration	Excavated soil is heated at high temperatures with oxygen to combust organic contaminants.	Treatment is on the order of weeks to months. Effective and reliable; off gases and combustion residuals generally require treatment.	Potentially implementable. Potentially difficult to acquire high-temperature treatment unit on short notice. Off-gas treatment likely necessary.	High Capital, Low O&M.	**Yes**
		Pyrolysis	Excavated soil is heated in the absence of oxygen to decompose organic contaminants into gaseous components and a solid residue.	Treatment is on the order of weeks to months. Effective for SVOCs and pesticides, potentially effective for other organics, and not effective for inorganics.	Potentially implementable. Likely difficult to acquire pyrolysis treatment unit on short notice. Gaseous and solid byproducts must be captured and then treated or disposed of.	High Capital, Low O&M.	No
		Thermal Desorption	Excavated soil is heated to volatilize organic contaminants, which are then transported to a gas treatment system. Thermal desorption physically separates contaminants and is not designed to destroy contaminants.	Treatment is on the order of weeks to months. Effective for organics, not effective for inorganics. Desorbed contaminants must be captured and treated or disposed of.	Potentially implementable. Potentially difficult to acquire thermal desporption treatment unit on short notice. Desorbed contaminants must be captured and then treated or disposed of.	High Capital, Low O&M.	**Yes**

Notes

EISB - Enhanced in-situ Bioremediation
EK - Electrokinetics
ISCO - in-situ Chemical Oxidation
ISCR - in-situ Chemical Reduction
MNA - Monitored Natural Attenuation
O&M - Operation & Maintenance
SVE - Soil Vapor Extraction
VI - Vapor Intrusion
VOCs - Volatile Organic Compounds
SVOCs- Semi-Volatile Organic Compounds

Table 2
Detailed Evaluation of Remedial Alternatives

Remedial Alternative	Threshold Criteria		Primary Balancing Criteria					Modifying Criteria	
	Overall Protection of Human Health and the Environment	**Compliance with Applicable or Relevant and Appropriate Requirements**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume of Contaminants**	**Short-Term Effectiveness**	**Implementability**	**Estimated Costs**	**State Acceptance**	**Community Acceptance**
Institutional Actions - Monitoring and Use Restrictions									
Monitored Natural Attenuation (MNA)									
Excavation and Off-Site Disposal									
Landfill Cap/Water Balance Cap									
In-Situ Enhanced Bioremediation (Reductive Dechlorination)									
In-Situ Chemical Oxidation (ISCO)									
Air Sparging/Soil Vapor Extraction (SVE)									
Ex-Situ Chemical Treatment: Chemical Oxidation	Increased risk to human health and the environment during ex-situ treatment, but overall protective of human health and the environment by permanamtly destroying contaminant mass.	Complies with federal and state environmental laws. Impacted leachate will need to be properly treated or disposed of, and VOC off-gassing may need to be treated to meet regulations.	Treatment is on the order of weeks to months. Treatment is effective and reliable if properly oxidants are added and properly distributed. Activated persulfate is effective for oxidation of Site contaminants. Contaminant mass is destoryed permanantly.	The volume and toxicity of Site contaminants would be reduced as contaminant mass is oxidized to non-toxic end products.	Removal of impacted material from the subsurface eliminates the potential for leaching into groundwater. However, leachate and off-gasses may be released to the environment during treatment.	Readily implementable. Relatively easy to acquire amendments. Leachate collection system necessary. Off-gas treatment may be necessary to control odors. Oxidants are hazardous materials requiring special safety precautions.	Capital and Construction: Annual O&M: Anticipated Duration: 30 Year NPV (5%):		
Ex-Situ Thermal Treatment: Incineration	Increased risk to human health and the environment during ex-situ treatment, but overall protective of human health and the environment by permanamtly destroying contaminant mass.	Complies with federal and state environmental laws. VOC off-gassing may need to be treated to meet regulations.	Treatment is on the order of weeks to months. Treatment is effective and reliable. Contaminant mass is destoryed permanantly.	The volume and toxicity of Site contaminants would be reduced as contaminant mass is combusted to non-toxic end products.	Removal of impacted material from the subsurface eliminates the potential for leaching into groundwater. However, off-gasses may be released to the environment during treatment.	Potentially implementable. Potentially difficult to acquire high-temperature treatment unit on short notice. Off-gas treatment likely necessary.	Capital and Construction: Annual O&M: Anticipated Duration: 30 Year NPV (5%):		
Ex-Situ Thermal Treatment: Thermal Desorption	Increased risk to human health and the environment during ex-situ treatment, but overall protective of human health and the environment by permanamtly removing contaminant mass from the subsurface.	Complies with federal and state environmental laws. Desorbed contaminants must be captured and then treated or disposed of, and VOC off-gassing may need to be treated to meet regulations.	Treatment is on the order of weeks to months. Treatment is effective for Site contaminants. Contaminant mass is permanantly removed from the subsurface.	The volume and toxicity of Site contaminants in the subsurface would be reducded as contaminant mass is seperated from the soil; however, the contaminants are not destroyed and must then be treated or disposed of.	Removal of impacted material from the subsurface eliminates the potential for leaching into groundwater. However, desorbed contaminants and off-gasses may be released to the environment during treatment.	Potentially implementable. Potentially difficult to acquire thermal desporption treatment unit on short notice. Desorbed contaminants must be captured and then treated or disposed of.	Capital and Construction: Annual O&M: Anticipated Duration: 30 Year NPV (5%):		